Inventory Audit Report
Upper Nass Zone of the Nass TSA

Revised November 1996

A report was released in August 1994 summarizing results and recommendations arising from an inventory audit conducted during 1993 for the Upper Nass Zone of the northern portion of the Kalum Timber Supply Area. It has since been noted that an improper field from the inventory database was used for some of the height projections, which affected the volume calculations. Since publication of the original report, the Kalum Timber Supply Area has been divided into the Kalum and the Nass Timber Supply Areas. This report covers the Upper Nass Zone of the new Nass TSA. The remainder of the Nass TSA and the new Kalum TSA underwent an inventory audit in the 1996 field season.

The inventory volume figures have been recalculated as shown in this revised report. The differences are minor, and no changes are necessary to the overall recommendations of the original report.

Introduction

In British Columbia, forest inventories for specific areas are conducted every 10 to 30 years, with regular updates between re-inventories to reflect changes in the forest due to growth and depletions.

The question "How accurate is the current inventory?" often arises. To answer this important question, the Ministry of Forests has developed an inventory audit methodology specifically designed to test the overall accuracy of estimates of the total standing volume in each timber supply area.

The Forest Inventory Program refers to this statistical auditing methodology as an Inventory Audit. The objective of the inventory audit is to help identify TFLs or TSAs where the forest inventory needs attention. Enough samples are taken to ensure statistically reliable results for the TSA as a whole.

The amount of data collected, however, is not sufficient to make statistically reliable conclusions about specific areas or tree species. For example, any overall differences highlighted by the audit could result from problems with one tree species, from part of the land base (such as high elevation rather than lower elevation areas), from one age group of forest stand, or from a combination of these and other factors. As a consequence, general audit results cannot appropriately be used to adjust information about the forests currently available for timber harvesting since the area sampled constitutes only a portion of the total forested area in the TSA.

The audits provide information that may be useful to the Chief Forester during determinations of the allowable annual cut—offering a general assessment of the uncertainty associated with mature timber volumes, immature site index, and the non-forest classification. However, the audit results cannot justifiably be used to make specific adjustments to growth and yield and other information used in timber supply analyses and allowable annual cut determinations.

This report presents the results of an inventory audit conducted in the Upper Nass Zone of the Nass Timber Supply Area (TSA) in Prince Rupert Forest Region. This area covers approximately 650 000 hectares, consisting mostly of forest stands with mature balsam and hemlock leading species.

The inventory for the Upper Nass Zone of the northern portion of the original Kalum TSA dates from 1979.

The primary objectives of conducting an audit in this area were to validate the timber inventory volumes and to check the reliability of the inventory audit methodology. To check the inventory audit methodology, two independent samples were collected by two different contractors on the same area.

Methods

Current inventory

The province is divided into 37 TSAs, which can vary from 70 000 hectares to 13 million hectares. Inventories can be performed on a complete TSA or on

a portion of it. Inventories are conducted by first delineating forest stands (polygons) on 1:15 000-scale aerial photographs. A number of photo-interpreted variables are assessed for each polygon, including species composition, stand height, age, and crown closure. Timber volume is then estimated indirectly using these photo-interpreted variables and empirical yield models.

To keep the estimates current, inventories are regularly updated to account for forest growth and depletions due to harvesting, fire, and the impact of insects and disease damage. Empirical yield models, such as the Ministry of Forests Variable Density Yield Prediction (VDYP) computer model, are used to update the inventory for forest growth; field visits, satellite imagery, and aerial photographs may be used to update for depletions.

The inventory audit for the Upper Nass Zone was based on two independent random samples of polygons selected from the target population of mature and immature forest stands.

For each of the polygons, the existing photo-interpreted variables, from the 1979 inventory, were projected to 1993 and fed into the VDYP model to obtain 1993 estimates of the volume per hectare (*inventory volume*).

The inventory volume estimates were then compared to volume estimates obtained from the audit sample (*audit volume*). This was done independently for each of the two sample populations that comprised this study.

Audit sample

Audit samples were selected from a polygon list from the 1979 inventory. To test the audit methodology, two independent samples were selected, resulting in a total of 51 sample polygons (24 in Sample A and 27 in Sample B). Up to 3 full-measure prism plots, and 9 count plots, were established within each of the 51 sample polygons. The plots were located systematically using a triangular design and a randomly selected start point. For large or irregular polygons, only a randomly selected portion of the polygon was sampled. A total of about 450 full-measure and count plots were established. Field data collection and compilation methods followed standard Ministry of Forests cruising and cruise compilation procedures. Utilization limits and merchantability definitions were chosen so that the compiled audit volumes would be comparable to the inventory volumes produced using the VDYP system.

The VDYP model produces net merchantable volumes per hectare, defined as whole-stem volume inside bark of all live trees of dbh 17.5+ cm, to a 10-cm diameter inside-bark top, and a 30-cm-high stump, excluding decay as estimated from Ministry loss factors. Dead potential and veteran trees are not included in the volume estimates.

For each of the two samples the audit volumes were then compared to the inventory volumes to test the validity of the current inventory. A comparison of the results for the two samples was used to comment on the technical merit of the inventory audit process.

Once the audit volumes were obtained, they were then compared to the inventory volumes to test the validity of the current inventory.

Revised results

Results of the statistical analysis of the inventory audit for volumes at 17.5 cm+ dbh utilization for Samples A and B are given in Tables 1 and 2, respectively. Table 3 presents the results of Samples A and B combined.

TABLE 1. Statistics for the audit volume and inventory volume estimates at 17.5+ cm dbh utilization (net decay) for Sample A in the Upper Nass Zone, Nass TSA

	Audit volume estimate	Inventory volume estimate
Number of samples	24	24
Mean (m^3/ha)	274	262
Coefficient of variation (%)	50	56
Standard error (m^3/ha)	27.7	29.7
Sampling error (%) at 95% confidence level	20.9	23.5
95% confidence interval (m^3/ha)	217–331	200–323
Correlation coefficient r = 0.793 (p-value = 0.001)		
Ratio of means (audit/inventory volume): 1.05		

TABLE 2: Statistics for the audit volume and inventory volume estimates at 17.5+ cm dbh utilization (net decay) for Sample B in the Upper Nass Zone, Nass TSA

	Audit volume estimate	Inventory volume estimate
Number of samples	27	27
Mean (m^3/ha)	271	305
Coefficient of variation (%)	35	29
Standard error (m^3/ha)	18.4	16.9
Sampling error (%) at 95% confidence level	13.9	11.4
95% confidence interval (m^3/ha)	233–309	271–340
Correlation coefficient r = 0.389 (p-value = 0.045)		
Ratio of means (audit/inventory volume): 0.89		

TABLE 3: Statistics for the audit volume and inventory volume estimates at 17.5+ cm dbh utilization (net decay) for Samples A and B combined, in the Upper Nass Zone, Nass TSA

	Audit volume estimate	Inventory volume estimate
Number of samples	51	51
Mean (m^3/ha)	272	285
Coefficient of variation (%)	42	42
Standard error (m^3/ha)	16.1	16.7
Sampling error (%) at 95% confidence level	11.9	11.8
95% confidence interval (m^3/ha)	240–305	251–318
Correlation coefficient r = 0.647 (p-value = 0.001)		
Ratio of means (audit/inventory volume): 0.96		

For Sample A, the calculated correlation coefficient of 0.793 for the audit and inventory volume estimates indicates a good relationship among the individual samples. There is a 12 m^3/ha difference between the mean audit estimate for mature volume (274 m^3/ha) and the mean inventory estimate for mature volume (262 m^3/ha) for Sample A. Sampling errors (at the 95% confidence level) are 20.9% and 23.5% respectively for the mean audit volume and mean inventory volume estimates. These sampling errors are greater than the maximum of 15% generally used as a standard for inventory volume estimation.

The ratio of mean audit volume to mean inventory volume for Sample A was 1.05. A two-sided paired-sample *t*-test shows that there is no significant difference between the estimates of mean volume per hectare for the audit and the inventory.

For Sample B, the calculated correlation coefficient of 0.389 for the audit and inventory volume estimates indicates a weak but statistically significant relationship among the individual samples. There is a 34 m^3/ha difference between the mean audit estimate for mature volume (271 m^3/ha) and the mean inventory estimate for mature volume (305 m^3/ha) for Sample B. Sampling errors (at the 95% confidence level) are 13.9% and 11.4% respectively for the mean audit volume and mean inventory volume estimates.

The ratio of mean audit volume to mean inventory volume for Sample B is 0.89. A two-sided paired-sample *t*-test shows that there is no significant difference between the estimates of mean volume per hectare for the audit and the inventory.

When Samples A and B are combined the results indicate a mean audit volume of 272 m^3/ha and a mean inventory volume of 285 m^3/ha. The sampling errors for these estimates are 11.9% and 11.8% respectively. The difference of 13 m^3/ha for the combined results is not statistically significant, 19 times out of 20.

Discussion and conclusions

The results of the inventory audit for the Upper Nass Zone of the Nass TSA suggest that the current inventory for timber volume (completed in 1979) is statistically acceptable. Neither of the two independent samples showed a significant difference between mean audit and inventory volumes per hectare.

Due to the minimal differences in volume and overlapping confidence intervals of the sample populations, further specific identification of inventory bias becomes difficult. The three data sets did not present a consistent trend that would enable further specific identification of the inventory differences.

With two independent audit volume estimates of 274 and 271 m^3/ha for samples A and B, respectively, these results indicate that the inventory audit sampling methodology, when applied in a consistent and unbiased fashion, will give an accurate estimate of the population average volume per hectare.

Glossary

accuracy: A measure of how close an estimate is to the true value.

allowable annual cut: The rate of timber harvesting specified for an area of land.

analysis unit: The basic building blocks around which inventory data and other information are organized for use in forest planning models, typically involving specific tree species or type groups that are further defined by site class, geographic location, or similarity of management regimes.

bias: The quality of a measurement device or procedures that tends to result in a systematic misrepresentation of what is being measured.

coefficient of variation: A relative measure of variation within a population, calculated as the ratio between the standard deviation and the mean value.

confidence interval: The range of values within which the population parameter is expected to lie.

confidence level: The estimated probability that a population parameter lies within a given confidence interval.

correlation coefficient: A measure of the relationship between two variables. A value of 0 for the correlation coefficient indicates a random relationship, whereas a value of ±1 indicates a perfect positive or negative linear correspondence.

dead potential trees: Standing or down dead timber which is estimated to contain at least 50% of its original gross volume in sound wood content.

diameter at breast height (dbh): The stem diameter (outside-bark) of a tree measured at breast height (1.3 metres above the point of germination) to the nearest millimetre.

field visitations: Ground-level field procedures designed to provide physical verification of polygon inventory attributes.

free-growing (crop): A crop of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, or other trees.

inoperable lands: Lands that are unsuited for timber production now and in the foreseeable future because of their topography, inaccessibility, low value of timber stands, or designation for uses incompatible with timber production.

mean: The average value of a set of observations.

polygon: A portion of land area, delineated on mid-scale aerial photographs, of "like" or uniform land cover type.

pre-inventory assessments: Inventory activities to evaluate the existing forest inventory as a basis for deciding whether to re-inventory or update the current inventory, and to document the existing inventory, maps, and photos to support the execution of the reinventory or update if required.

public sustained yield units (PSYU): A portion of a TSA; an area of Crown land, usually a natural topographic unit determined by drainage areas, managed for sustained yield by the Crown through the Ministry of Forests. It includes all Crown lands within the currently established boundaries of the unit, and excludes federal lands, provincial parks, experimental forest reserves, gazetted watersheds and tree farm licences.

ratio estimate: The ratio between two different estimates.

representative: The quality of a sample having the same characteristics as the population from which it is selected.

sampling: The process of selecting observations.

sampling error: The error attributed to sampling procedures.

significant difference: The results of a statistical test comparing either two or more estimates, or an estimate to a fixed value. If the difference is too large to be attributed to chance, the difference is said to be statistically significant.

site index: An expression of the forest site quality of a stand, at a specified age, based either on the site height, or on the top height, which is a more objective measure.

standard error: An expression of the absolute variability of an estimate.

standard deviation: A measure of the variation of the population.

timber supply analysis: An assessment of future timber supplies over long planning horizons (more than 200 years) by using timber supply models for different scenarios identified in the planning process.

timber supply area (TSA): An area defined by an established pattern of wood flow from management units to the primary timber-using industries.

tree farm licence (TFL): Privately managed Sustained Yield Units; designed to enable owners of Crown-granted forest lands and old temporary tenures or the timber licences which replace them, to combine these with enough unencumbered Crown land to form self-contained sustained yield management units.

variable density yield prediction (VDYP) model: An empirical yield-prediction system for natural stands based on data collected in temporary inventory sample plots (TSPs) and natural, permanent growth sample plots (PSPs). VDYP predicts volume (net decay) and diameters at four utilization levels using stand height, age, and density. The aerial approach uses crown closure as the density measure.

veteran trees: Mature living trees which are remnants of an older stand.

For more information

For more information or to obtain other inventory audit reports, contact: Director, Resources Inventory Branch, B.C. Ministry of Forests, 722 Johnson Street, Victoria, B.C., Canada V8W 3E7 Phone 250-387-1314 Fax 250-387-5999. Visit our web site at http://www.for.gov.bc.ca/resinv/homepage.htm

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